

Green-Mode PFC / Forward PWM Controller

SG6932

FEATURES OVERVIEW

- Interleaved PFC / PWM switching
- Green-mode PFC and PWM operation
- Low operating current
- Innovative switching-charge multiplier-divider
- Multi-vector control for improved PFC output transient response
- Average-current-mode for input-current shaping
- PFC over-voltage and under-voltage protections
- PFC and PWM feedback open-loop protection
- Cycle-by-cycle current limiting for PFC/PWM
- Slope compensation for PWM
- Selectable PWM maximum duty cycle 50% and 65%
- Brownout protection
- Power-on sequence control and soft-start

APPLICATIONS

- Switch-mode power supplies with active PFC
- Servo system power supplies
- PC-ATX power supplies

DESCRIPTION

The highly integrated SG6932 is designed for power supplies with boost PFC and forward PWM. It requires very few external components to achieve green-mode operation and versatile protections / compensation. It is available in 16-pin DIP and SOP packages.

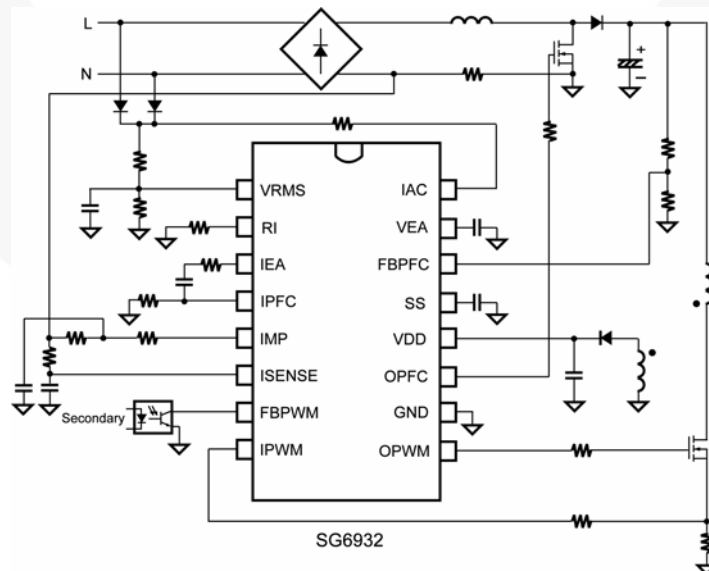
The patented interleave-switching feature synchronizes the PFC and PWM stages and reduces switching noise. At light load, the switching frequency is continuously decreased to reduce power consumption.

For PFC stage, the proprietary multi-vector control scheme provides a fast transient response in a low-bandwidth PFC loop, in which the overshoot and undershoot of the PFC voltage are clamped. If the feedback loop is broken, SG6932 shuts off to prevent extra-high voltage on output.

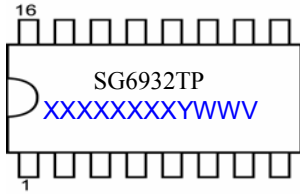
For the Forward PWM stage, the synchronized slope compensation ensures the stability of the current loop under continuous-conduction-mode operation. Hiccup operation during output overloading is guaranteed. The soft-start and programmable maximum duty cycle ensure safe operation.

SG6932 provides complete protection functions, such as brownout protection and RI open/short latch off.

TYPICAL APPLICATION

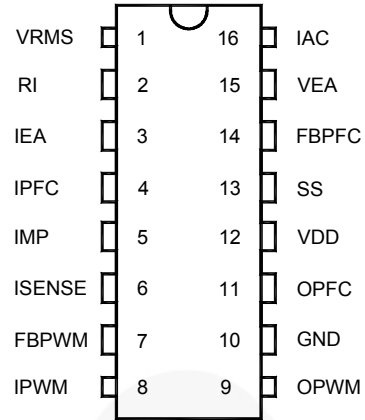


MARKING DIAGRAMS



T: D=DIP, S=SOP
 P: Z =Lead Free + ROHS
 Compatible
 XXXXXXXX: Wafer Lot
 Y: Year; WW: Week
 V: Assembly Location

PIN CONFIGURATION



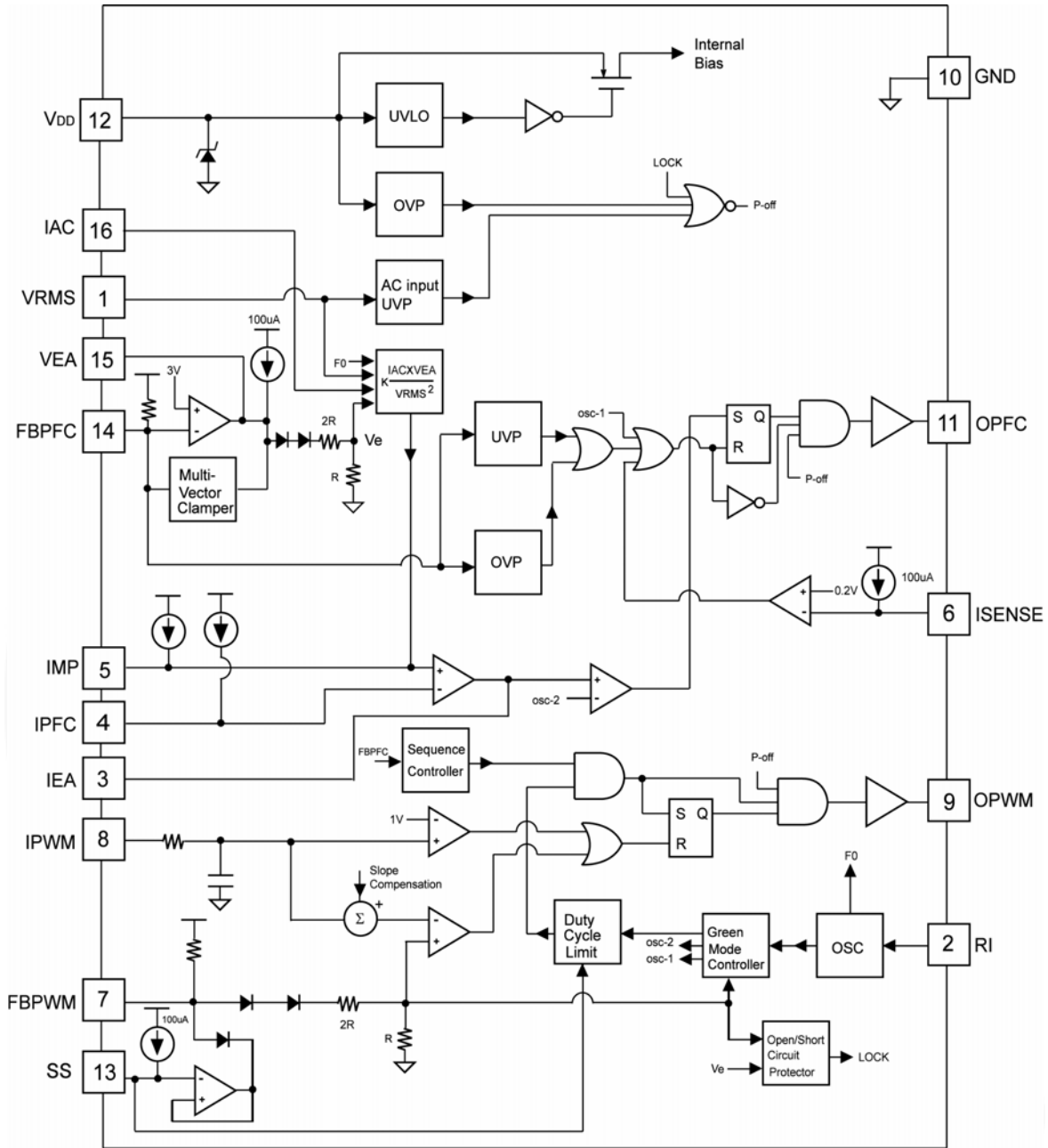
ORDERING INFORMATION

Part Number	Pb-Free	Package
SG6932DZ		16-pin DIP
SG6932SZ (Preliminary)		16-pin SOP

PIN DESCRIPTIONS

Name	Pin No.	Type	Function
VRMS	1	Line-Voltage Detection	Line voltage detection. The pin is used for PFC multiplier and brownout protection.
RI	2	Oscillator Setting	Reference setting. One resistor connected between RI and ground determines the switching frequency. A resistor with resistance between 12k ~ 47kΩ is recommended. The switching frequency is equal to $[1560 / R_i]$ kHz, where R_i is in kΩ. For example, if R_i is 24kΩ, the switching frequency is 65kHz.
IEA	3	Output of PFC Current Amplifier	This is the output of the PFC current amplifier. The signal from this pin is compared with an internal sawtooth and determines the pulse width for PFC gate drive.
IPFC	4	Inverting Input of PFC Current Amplifier	The inverting input of the PFC current amplifier. Proper external compensation circuits result in excellent input power factor via average-current-mode control.
IMP	5	Non-inverting Input of PFC Current Amplifier and Output of Multiplier	The non-inverting input of the PFC current amplifier and the output of the multiplier. Proper external compensation circuits result in excellent input power factor via average current mode control.
ISENSE	6	Peak Current Limit Setting for PFC	The peak current limit setting for PFC.
FBPWM	7	PWM Feedback Input	The control input for voltage-loop feedback of PWM stage. It is internally pulled high through a 6.5kΩ resistance. Usually an external opto-coupler from secondary feedback circuit is connected to this pin.
IPWM	8	PWM Current Sense	The current sense input for the PWM stage. Via a current sense resistor, this pin provides the control input for peak-current-mode control and cycle-by-cycle current limiting.
OPWM	9	PWM Gate Drive	The totem pole output drive for PWM MOSFET. This pin is internally clamped under 18V to protect the MOSFET.
GND	10	Ground	The power ground.
OPFC	11	PFC Gate Drive	The totem pole output drive for the PFC MOSFET. This pin is internally clamped under 18V to protect the MOSFET.
VDD	12	Supply	The power supply pin. The threshold voltages for start-up and turn-off are 14V and 10V, respectively. The operating current is lower than 10mA.
SS	13	PWM Soft-Start	During start-up, the SS pin charges an external capacitor with a 50μA constant current source. The voltage on FBPWM is clamped by SS during start-up. In the event of a protection condition occurring and/or PWM being disabled, the SS pin is quickly discharged. The voltage of SS pin can be used to select 50% or 65% maximum duty cycle.
FBPFC	14	Voltage Feedback Input for PFC	The feedback input for PFC voltage loop. The inverting input of PFC error amplifier. This pin is connected to the PFC output through a divider network.
VEA	15	Error Amplifier Output for PFC Voltage Feedback Loop	The error amplifier output for PFC voltage feedback loop. A compensation network (usually a capacitor) is connected between this pin and ground. A large capacitor value results in a narrow bandwidth and improves the power factor.
IAC	16	Input AC Current	For normal operation, this input is used to provide current reference for the multiplier. The suggested maximum I_{AC} is 360μA.

BLOCK DIAGRAM



Green-Mode PFC / Forward PWM Controller
SG6932
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Test Conditions	Value	Unit	
V _{DD}	DC Supply Voltage*		25	V	
I _{AC}	Input AC Current		2	mA	
V _{High}	OPWM, OPFC, IAC		-0.5 to 25V	V	
V _{Low}	Others	At T _A <50°C	-0.5 to 7V	V	
P _D	Power Dissipation		0.8	W	
T _J	Operating Junction Temperature		-40 to 125	°C	
T _{stg}	Storage Temperature Range		-55 to +150	°C	
R _{θJC}	Thermal resistance (Junction-to-Case)		DIP	33.64	°C/W
			SOP	41.95	
T _L	Lead Temperature (Wave soldering, 10 seconds)		260	°C	
ESD	Electrostatic Discharge Capability, Human Body Model		4.5	KV	
	Electrostatic Discharge Capability, Machine Model		250	V	

*All voltage values, except differential voltages, are given with respect to the network ground terminal.

RECOMMENDED OPERATING JUNCTION TEMPERATURE: -30°C~ 85°C*

* For proper operation.

ELECTRICAL CHARACTERISTICS

V_{DD}=15V, T_A=25°C unless otherwise noted.

V_{DD} Section

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{DD-OP}	Continuously Operating Voltage				20	V
I _{DD-ST}	Start-Up Current	V _{DD} -0.16V		10	20	μA
I _{DD-OP}	Operating Current	V _{DD} =15V; OPFC OPWM open		6	10	mA
V _{TH-ON}	Start Threshold Voltage		13	14	15	V
V _{DD-min}	Min. Operating Voltage		9	10	11	V
V _{DD-OVP}	VDD OVP1 (turn off PWM with delay)		23.5	24.5	25.5	V
T _{VDD-OVP}	Delay time of VDD OVP1	R _I =24kΩ	8		25	μs

Oscillator & Green-Mode Operation

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{RI}	RI Voltage		1.176	1.200	1.224	V
F _{OSC}	PWM Frequency	R _I =24kΩ	62	65	68	KHz
F _{OSC-MINFREQ}	Minimum Frequency in Green Mode	R _I =24kΩ	18	20	22	KHz
RI	RI Range		12		47	kΩ
RI _{OPEN}	RI Pin Open Protection If RI > RI _{open} , PWM Turned Off			200		kΩ
RI _{SHORT}	RI Pin Short Protection If RI < RI _{short} , PWM Turned Off			2		kΩ

Green-Mode PFC / Forward PWM Controller

SG6932

V_{RMS} for UVP and ON/OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{RMS-UVP-1}	RMS AC Voltage Under-Voltage Threshold to Turn Off PFC (with T _{UVP} Delay) for UVP Mode1		0.75	0.8	0.85	V
V _{RMS-UVP-2}	Recovery Level on V _{RMS} for UVP		V _{RMS-UVP-1} + 0.17V	V _{RMS-UVP-1} + 0.19V	V _{RMS-UVP-1} + 0.21V	V
T _{UVP}	Under-Voltage Protection Propagation to Turn Off PFC Delay Time (No Delay for Start-up)	R _i =24kΩ	150	195	240	ms

PFC Stage

Voltage Error Amplifier

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{REF}	Reference Voltage		2.95	3.00	3.05	V
A _v	Open-Loop Gain			60		dB
Z _o	Output Impedance			110		kΩ
OVP _{FBPFC}	PFC Over-voltage Protection		3.20	3.25	3.30	V
ΔOVP _{FBPFC}	PFC Feedback Voltage Protection Hysteresis		60	90	120	mV
V _{FBPFC-H}	Clamp-High Feedback Voltage		3.10	3.15	3.20	V
G _{FBPFC-H}	Clamp-High Gain			0.5		mA/V
V _{FBPFC-L}	Clamp-Low Feedback Voltage		2.75	2.85	2.90	V
G _{FBPFC-L}	Clamp-Low Gain			6.5		mA/mV
I _{FBPFC-L}	Maximum Source Current		1.5	2.0		mA
I _{FBPFC-H}	Maximum Sink Current		70	110		μA
UVP _{VFB}	PFC Feedback Under-Voltage Protection		0.35	0.40	0.45	V
V _{FBHIGH}	Output High Voltage on V _{EA}		6	7	8	V
V _{RD-FBPFC}	Voltage level on FBPFC to Enable OPWM During Start-up		2.6	2.7	2.8	V
T _{UVP-PFC}	Debounce Time of PFC UVP		40	70	120	μs

Current Error Amplifier

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{OFFSET}	Input Offset Voltage ((-) > (+))			8		mV
A _i	Open-loop Gain			60		dB
BW	Unit Gain Bandwidth			1.5		MHz
CMRR	Common-mode Rejection Ratio	V _{CM} =0 ~ 1.5V		70		dB
V _{OUT-HIGH}	Output High Voltage		3.2			V
V _{OUT-LOW}	Output Low Voltage				0.2	V
I _{MR1} , I _{MR2}	Reference Current Source	R _i =24kΩ (I _{MR} =20+I _{R1} *0.8)	50		70	μA
I _L	Maximum Source Current			3		mA
I _H	Maximum Sink Current			0.25		mA

Green-Mode PFC / Forward PWM Controller
SG6932
Peak Current Limit

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_P	Constant Current Output	$R_I=24k\Omega$	90	100	110	μA
V_{pk}	Peak Current Limit Threshold Voltage	$V_{RMS}=1.05V$	0.15	0.20	0.25	V
	Cycle-by-Cycle Limit ($V_{sense} < V_{pk}$)	$V_{RMS}=3V$	0.35	0.40	0.45	V
T_{pkD}	Propagation Delay				200	ns
Bnkt	Leading-Edge Blanking Time		270	350	450	ns

Multiplier

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{AC}	Input AC Current	Multiplier Linear Range	0		360	μA
I_{MO-max}	Maximum Multiplier Current Output;	$R_I=24k\Omega$		230		μA
I_{MO-1}	Multiplier Current Output (Low-Line, High-Power)	$V_{RMS}=1.05V$; $I_{AC}=90\mu A$; $V_{EA}=7.5V$; $R_I=24k\Omega$	200	230	280	μA
I_{MO-2}	Multiplier Current Output (High-Line, High-Power)	$V_{RMS}=3V$; $I_{AC}=264\mu A$; $V_{EA}=7.5V$; $R_I=24k\Omega$	65	85		μA
V_{IMP}	Voltage of IMP Open		3.4	3.9	4.4	V

PFC Output Driver

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{Z-PFC}	Output Voltage Maximum (Clamp)	$V_{DD}=20V$		16	18	V
V_{OL-PFC}	Output Voltage Low	$V_{DD}=15V$; $I_O=100mA$			1.5	V
V_{OH-PFC}	Output Voltage High	$V_{DD}=13V$; $I_O=100mA$	8			V
T_{R-PFC}	Rising Time	$V_{DD}=15V$; $C_L=5nF$; $O/P=2V$ to $9V$	40	70	120	ns
T_{F-PFC}	Falling Time	$V_{DD}=15V$; $C_L=5nF$; $O/P=9V$ to $2V$	40	60	110	ns
$DC_{(MAX)}$	Maximum Duty Cycle		93		97	%

PWM Stage
FBPWM

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
A_V	FB to Current Comparator Attenuation		2.2	2.7	3.2	V/V
Z_{FB}	Input Impedance		4	5	7	$k\Omega$
$FB_{OPEN-LOOP}$	PWM Open-Loop Protection Voltage		4.2	4.5	4.8	V
$T_{OPEN-PWM-Hiccup}$	Interval of PWM Open-Loop Protection Reset	$R_I=24k\Omega$	500	600	700	ms
$T_{OPEN-PWM}$	PWM Open-Loop Protection Delay Time	$R_I=24k\Omega$	80	95	120	ms
V_N	Frequency Reduction Threshold on FBPWM		1.9	2.1	2.3	V
S_G	Green-Mode Modulation Slope		60	75	90	Hz/mV
V_G	Voltage on FBPWM for Minimum Green-Mode Frequency		1.35	1.60	1.75	V

Green-Mode PFC / Forward PWM Controller

SG6932

PWM-Current Sense

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T _{PD-PWM}	Propagation Delay to Output – V _{LIMIT} Loop	V _{DD} =15V, OPWM drops to 9V	60		120	ns
V _{LIMIT}	Peak Current Limit Threshold Voltage		0.65	0.70	0.75	V
T _{BNK-PWM}	Leading-Edge Blanking Time		270	350	450	ns
ΔV _{SLOPE}	Slope Compensation ΔV _s =ΔV _{SLOPE} × (T _{on} /T) ΔV _s : Compensation Voltage Added to Current Sense		0.40	0.45	0.55	V

Output Driver

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{Z-PWM}	Output Voltage Maximum (Clamp)	V _{DD} =20V		16	18	V
T _{PWM}	Interval of OPWM Lags Behind OPFC at Start-up	R _I =24kΩ	2	4	6	ms
V _{OL-PWM}	Output Voltage Low	V _{DD} =15V; I _O =100mA			1.5	V
V _{OH-PWM}	Output Voltage High	V _{DD} =13V; I _O =100mA	8			V
T _{R-PWM}	Rising Time	V _{DD} =15V; C _L =5nF; O/P=2V to 9V	30	60	120	ns
T _{F-PWM}	Falling Time	V _{DD} =15V; C _L =5nF; O/P=9V to 2V	30	50	110	ns

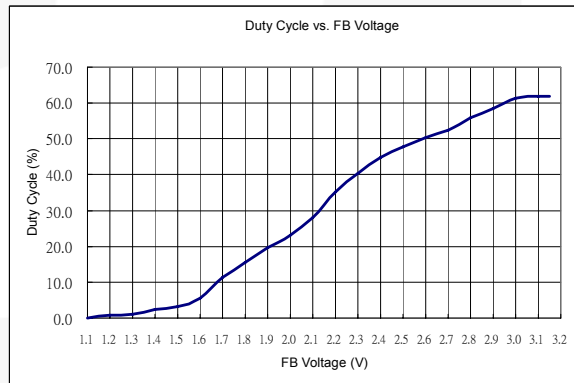
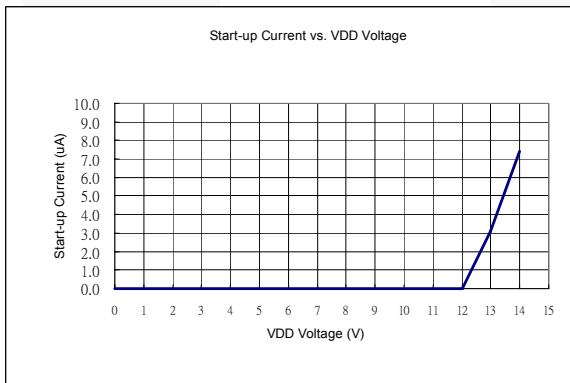
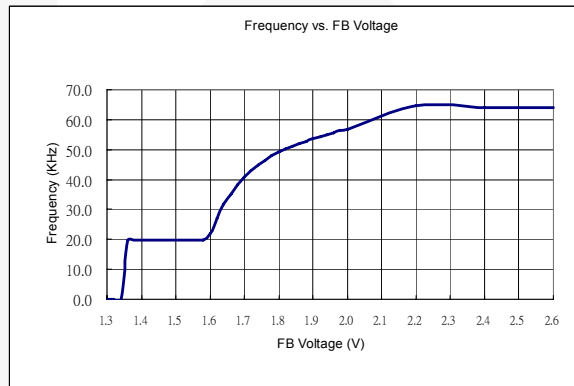
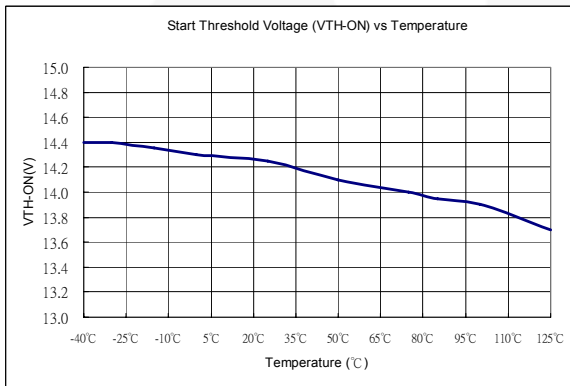
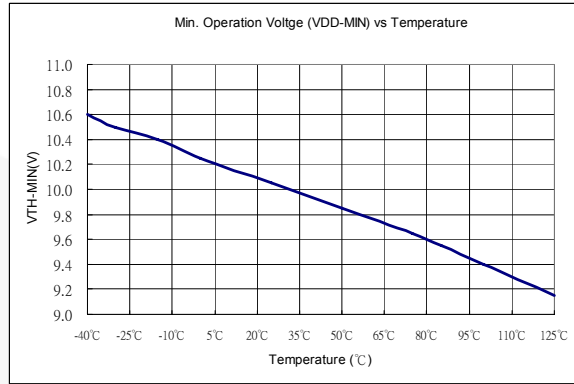
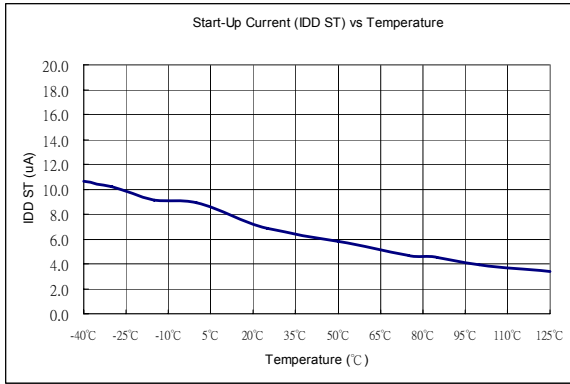
Maximum Duty Cycle

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
DC _{SS=6V}	Maximum Duty Cycle for SS=6V	R _I =24kΩ	62		66	%
DC _{SS=5V}	Maximum Duty Cycle for SS=5V	R _I =24kΩ	46		50	%

Soft-Start

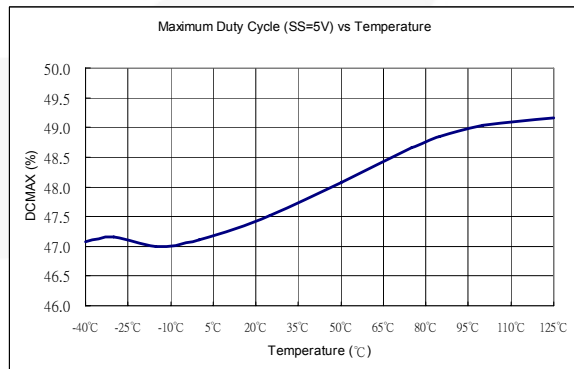
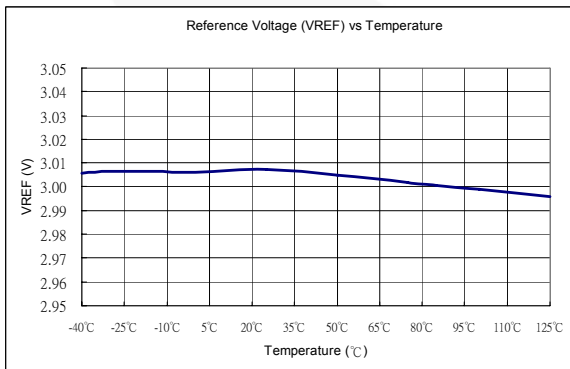
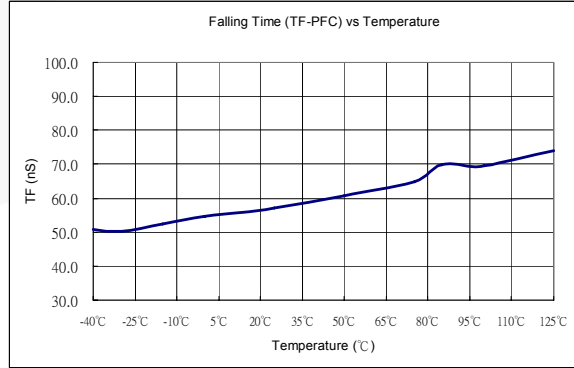
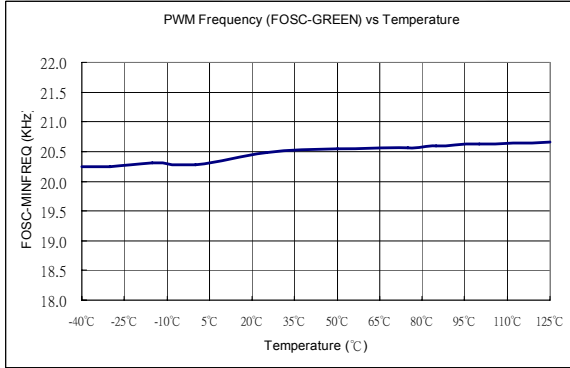
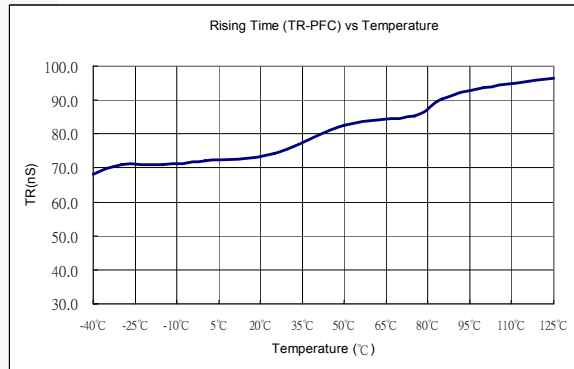
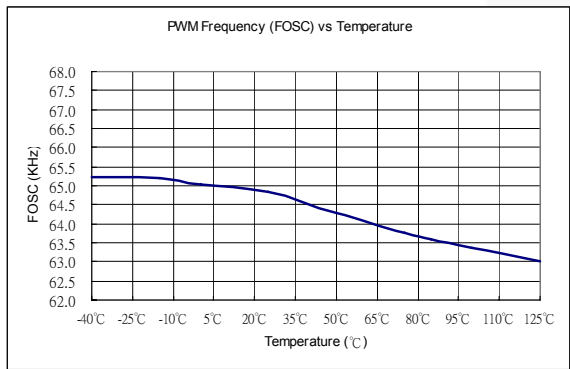
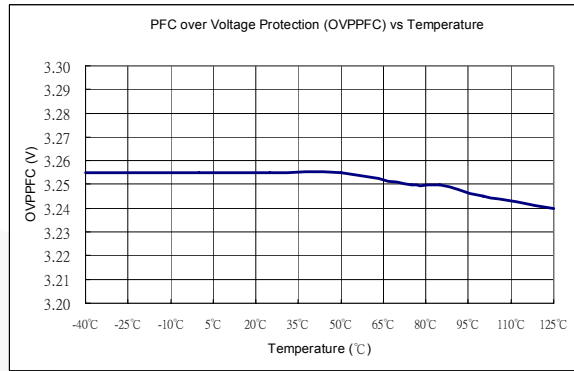
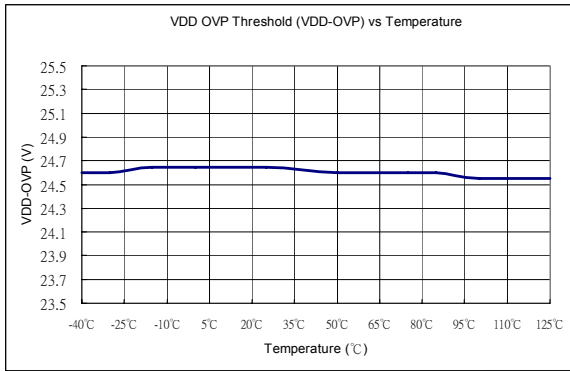
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I _{SS}	Constant Current Output for Soft-Start	R _I =24kΩ	44	50	56	μA
V _{DC-MAX-50%}	Voltage of SS for 50% Maximum Duty Cycle				5	V
V _{DC-MAX-65%}	Voltage of SS for 65% Maximum Duty Cycle		6			V
R _D	Discharge Resistance			470		Ω

TYPICAL CHARACTERISTICS



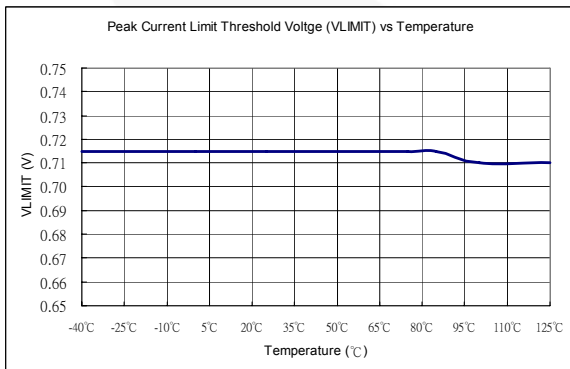
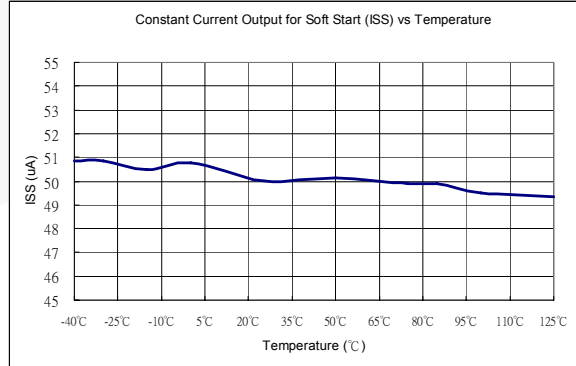
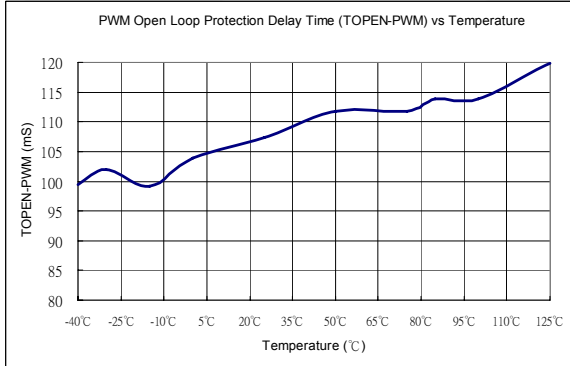
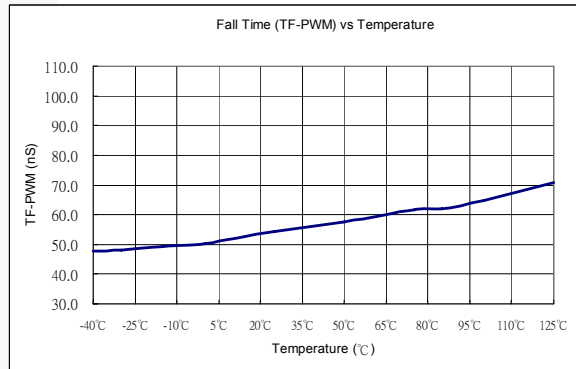
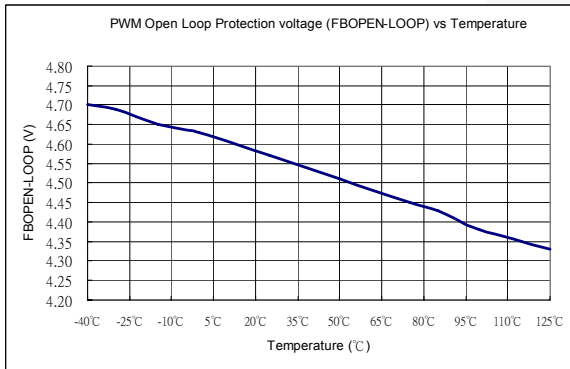
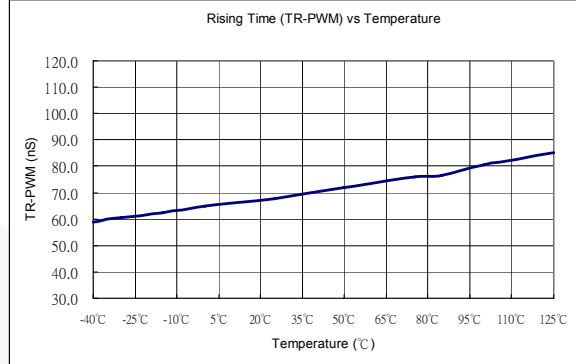
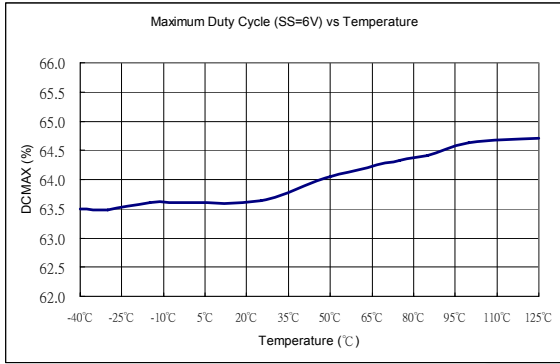
Green-Mode PFC / Forward PWM Controller

SG6932



Green-Mode PFC / Forward PWM Controller

SG6932



OPERATION DESCRIPTION

The highly integrated SG6932 is designed for power supplies with boost PFC and forward PWM. It requires very few external components to achieve green-mode operation and versatile protections / compensation.

The patented interleave-switching feature synchronizes the PFC and PWM stages and reduces switching noise. At light load, the switching frequency is linearly decreased to reduce power consumption.

The PFC function is implemented by average-current-mode control. The patented switching charge multiplier-divider provides high-degree noise immunity for the PFC circuit. This also enables the PFC circuit to operate over a much wider region. The proprietary multi-vector output voltage control scheme provides a fast transient response in a low-bandwidth PFC loop, in which the overshoot and undershoot of the PFC voltage are clamped. If the feedback loop is broken, the SG6932 shuts off PFC to prevent extra-high voltage on output.

For the forward PWM, the synchronized slope compensation ensures the stability of the current loop under continuous-mode operation. Hiccup operation during output overloading is also guaranteed. To prevent the power supply from drawing large current during start-up, the start-up for PWM stage is delayed 4ms after the PFC output voltage reaches its setting value.

In addition, SG6932 provides complete protection functions such as brownout protection and built-in latch for over-voltage and RI open/short.

I_{AC} signal

Figure 1 shows the IAC pin connected to input voltage by a resistance and the current, I_{AC}, is the input for PFC multiplier. For the linear range of I_{AC} 0~360μA, the range input voltage should be connected a resistance over 1.2M.

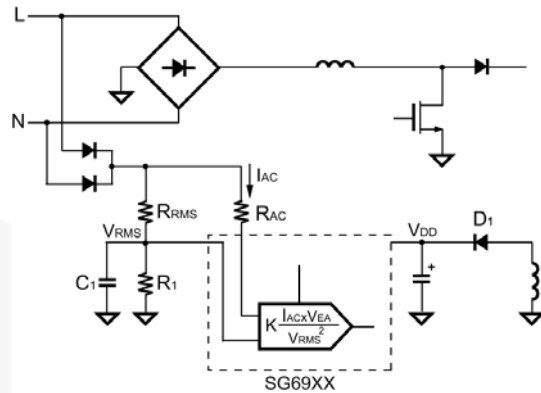


Figure 1. Input Voltage Detection

Switching Frequency / Current Sources

The switching frequency of SG6932 can be programmed by the resistor R_I connected between RI pin and GND. The relationship is:

$$f_{PWM} = \frac{1560}{R_I \text{ (k}\Omega\text{)}} \text{ (kHz)} \text{ ----- (1)}$$

For example, a 24kΩ resistor R_I results in a 65kHz switching frequency. Accordingly, constant current I_T flows through R_I.

$$I_T = \frac{1.2V}{R_I \text{ (k}\Omega\text{)}} \text{ (mA)} \text{ ----- (2)}$$

I_T is used to generate internal current reference.

Line Voltage Detection (V_{RMS})

Figure 2 shows a resistive divider with low-pass filtering for line-voltage detection on V_{RMS} pin. The V_{RMS} voltage is used for the PFC multiplier and brownout protection. For brownout protection, when the V_{RMS} voltage drops below 0.8V, OPFC turns off.

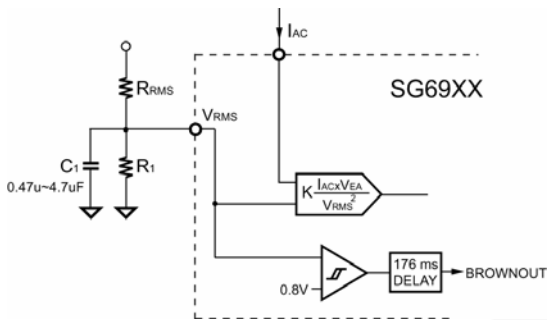


Figure 2. Line-Voltage Detection on VRMS Pin

Interleave Switching / Green-Mode

The SG6932 uses interleaved switching to synchronize the PFC and PWM stages. This reduces switching noise and spreads the EMI emissions. Figure 3 shows off-time (T_{OFF}) inserted between the turn-off of the PFC gate drives and the turn-on of the PWM.

The off-time (T_{OFF}) is increased in response to the decreasing of the voltage level of FBPWM; therefore, the PWM switching frequency is linearly decreased to reduce switching losses.

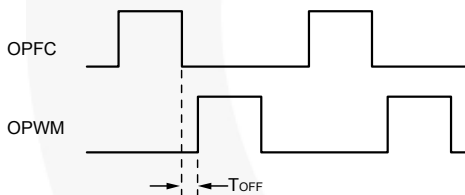


Figure 3. Interleaved Switching

PFC Operation

The purpose of a boost active power factor corrector (PFC) is to shape the input current of a power supply. The input current waveform and phase follow that of the input voltage. Using SG6932, average-current-mode control is utilized for continuous-current-mode operation for the PFC booster. With the innovative multi-vector control for voltage loop and switching-charge multiplier-divider for current reference, excellent input power factor is achieved with good noise immunity and transient response. Figure 4 shows the total control loop for the average-current-mode control circuit of SG6932.

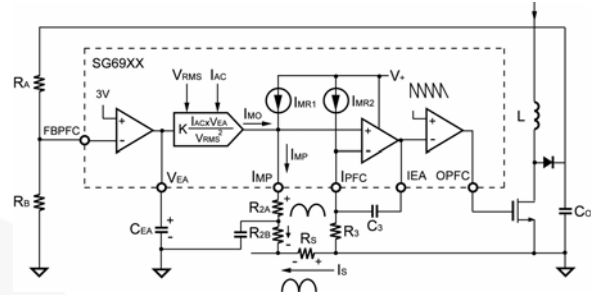


Figure 4. Control Loop of PFC Stage

The current source output from the switching charge multiplier-divider can be expressed as:

$$I_{MO} = K \times \frac{I_{AC} \times V_{EA}}{V_{RMS}^2} (\mu A) \quad (3)$$

I_{IMP} , the current output from IMP pin, is the summation of I_{MO} and I_{MR1} . I_{MR1} and I_{MR2} are identical fixed-current sources. R_2 and R_3 are also identical. They are used to pull high the operating point of the IMP and IPFC pins when the voltage across R_S goes negative with respect to ground.

Through the differential amplification of the signal across R_S , better noise immunity is achieved. The output of IEA is compared with an internal sawtooth and the pulse width for PFC is determined. Through the average current-mode control loop, the input current I_S is proportional to I_{MO} :

$$I_{MO} \times R_2 = I_S \times R_S \quad (4)$$

According to Equation 4, the minimum value of R_2 and maximum of R_S can be determined since I_{MO} should not exceed the specified maximum value.

There are different concerns in determining the value of the sense resistor, R_S . The value of R_S should be small enough to reduce power consumption, but large enough to maintain the resolution. A current transformer (CT) may be used to improve the efficiency of high power converters.

To achieve good power factor, the voltage for V_{RMS} and V_{EA} should be kept as DC as possible, according to Equation 3. Good RC filtering for V_{RMS} and narrow bandwidth (lower than the line frequency) for voltage loop are suggested for better input current shaping. The

Green-Mode PFC / Forward PWM Controller

SG6932

transconductance error amplifier has output impedance $R_O (>90k\Omega)$ and a capacitor C_{EA} ($1\mu F \sim 10\mu F$) connected to ground (as shown in Figure 5). This establishes a dominant pole f_1 for the voltage loop:

$$f_1 = \frac{1}{2\pi \times R_O \times C_{EA}} \tag{5}$$

The average total input power can be expressed as:

$$\begin{aligned} P_{in} &= V_{in}(rms) \times I_{in}(rms) \\ &\propto V_{RMS} \times I_{MO} \\ &\propto V_{RMS} \times \frac{I_{AC} \times V_{EA}}{V_{RMS}^2} \\ &\propto V_{RMS} \times \frac{V_{in}}{R_{AC}} \times V_{EA} \\ &\propto V_{RMS} \times \frac{R_{AC}}{V_{RMS}^2} \propto V_{EA} \end{aligned} \tag{6}$$

From Equation 6, V_{EA} , the output of the voltage error amplifier, actually controls the total input power and the power delivered to the load.

Multi-Vector Error Amplifier

The voltage-loop error amplifier is transconductance, which has high output impedance ($> 90k\Omega$). A capacitor C_{EA} ($1\mu F \sim 10\mu F$) connected from V_{EA} to ground provides a dominant pole for the voltage loop. Although the PFC stage has a low bandwidth voltage loop for better input power factor, the innovative multi-vector error amplifier provides a fast transient response to clamp the overshoot and undershoot of the PFC output voltage.

Figure 5 shows the block diagram of the multi-vector error amplifier. When the variation of the feedback voltage exceeds $\pm 5\%$ of the reference voltage, the transconductance error amplifier adjusts its output impedance to increase the loop response. If R_A is opened, SG6932 shuts off immediately to prevent extra-high voltage on the output capacitor.

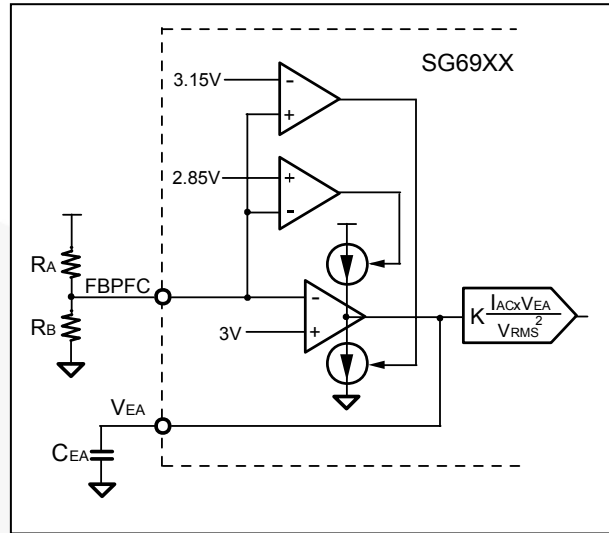


Figure 5. Multi-Vector Error Amplifier

Cycle-by-Cycle Current Limiting

SG6932 provides cycle-by-cycle current limiting for both PFC and PWM stages. Figure 6 shows the peak current limit for the PFC stage. The PFC gate drive is terminated once the voltage on the ISENSE pin goes below V_{PK} .

The voltage of V_{RMS} determines the voltage of V_{PK} . The relationship between V_{PK} and V_{RMS} is shown in Figure 6.

The amplitude of the constant current, I_p , is determined by the internal current reference, I_T , according to the equation:

$$I_p = 2 \times I_T = 2 \times \frac{1.2V}{R_1} \tag{7}$$

Therefore, the peak current of the I_s is given by ($V_{RMS} < 1.05V$):

$$I_{s_peak} = \frac{(I_p \times R_P) - 0.2V}{R_s} \tag{8}$$

Green-Mode PFC / Forward PWM Controller

SG6932

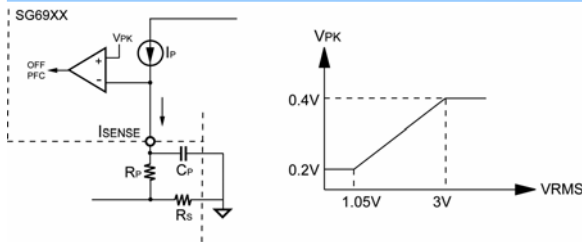


Figure 6. Current Limit

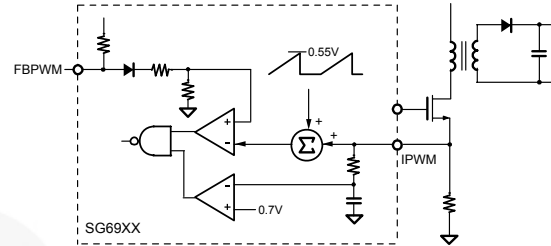


Figure 8. Slope Compensation

Power-On Sequence / Soft-Start

The SG6932 is enabled whenever the line voltage is higher than the brownout threshold. Once the SG6932 is active, the PFC stage is enabled first. The PWM stage is enabled following a 4ms delay after FBPF voltage exceeds 2.7V. During start-up of PWM stage, the SS pin charges an external capacitor with a constant-current source. The voltage on FBPWM is clamped by SS during start-up. In the event of a protection condition occurring and/or PWM being disabled, the SS pin is quickly discharged.

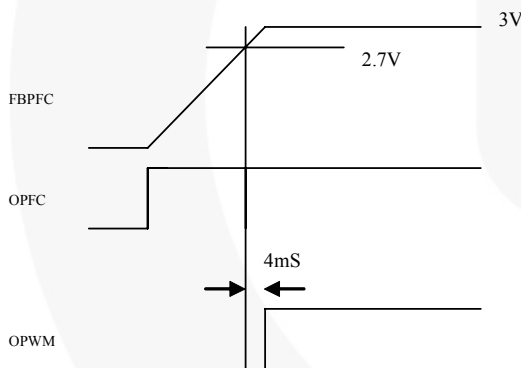


Figure 7. Power-On Sequence

Forward PWM and Slope Compensation

The PWM stage is designed for forward power converters. Peak current mode control is used to optimize system performance. Slope compensation is added to stabilize the current loop. The SG6932 inserts a synchronized positively sloped ramp at each switching cycle. The positively sloped ramp is represented by the voltage signal V_{s-comp} . In the example in Figure 8, the ramp signal voltage is 0.55V.

Limited Power Control

Every time the output of power supply is shorted or overloaded, the FBPWM voltage increases. If the FB voltage is higher than a designed threshold, 4.2V, for longer than 95ms, the PWM output is turned off.

Gate Drivers

SG6932 output stages are fast totem-pole gate drivers. The output driver is clamped by an internal 18V Zener diode to protect the power MOSFET.

Protections

The SG6932 provides full protection functions to prevent the power supply and the load from being damaged. The protection features include:

PFC Feedback Over-Voltage Protection. When the PFC feedback voltage exceeds the over-voltage threshold, the SG6932 inhibits the PFC switching signal. This protection also prevents the PFC power converter from operating abnormally while the FBPF pin is open.

Second PFC Over-Voltage Protection (OVP_PFC). The PFC stage over-voltage input. The comparator disables the PFC output driver if this input exceeds 3.25V. This pin can be connected to the FBPF pin or the PFC boost output through a divider network. This pin provides an extra input for PFC over-voltage protection.

PFC Feedback Under-Voltage Protection. The SG6932 stops the PFC switching signal whenever the PFC feedback voltage drops below the under-voltage threshold. This protection feature is designed to prevent the PFC

Green-Mode PFC / Forward PWM Controller

SG6932

power converter from experiencing abnormal conditions while the FBPF pin is shorted to ground.

V_{DD} Over-Voltage Protection. The PFC and PWM stages are disabled whenever the V_{DD} voltage exceeds the over-voltage threshold.

RI Pin Open / Short Protection. The RI pin is used to set the switching frequency and internal current reference. The PFC and PWM stages of SG6932 are disabled whenever the RI pin is short or open.

PCB Layout

SG6932 has a single ground pin, which prevents high sink currents in the output being returned separately. Good high-frequency or RF layout practices should be followed. Avoid long PCB traces and component leads. Locate decoupling capacitors near the SG6932. A resistor of 5 ~ 20Ω is recommended, connected in series from the output to the gate of the MOSFET.

Isolating the interference between the PFC and PWM stages is also important. Figure 9 shows an example of the PCB layout. The *ground trace 1* is connected from the ground pin of SG6932 to the decoupling capacitor, which should be low impedance and as short as possible. The *ground trace 2* provides a signal ground. It should be connected directly to the decoupling capacitor C_{DD} and/or to the ground pin of the SG6932. The *ground trace 3* is

independently tied from the decoupling capacitor to the PFC output capacitor C_O. The ground in the output capacitor C_O is the major ground reference for power switching. To provide a good ground reference and reduce the switching noise of both the PFC and PWM stages, the *ground traces 6 and 7* should be located very near and be low impedance.

The IPFC pin is connected directly to R_S through R₃ to improve noise immunity. Do not incorrectly connect to the ground trace 2. The IMP and ISENSE pins should be connected directly via the resistors R₂ and R_P to another terminal of R_S.

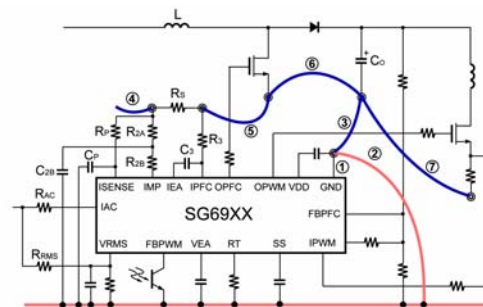
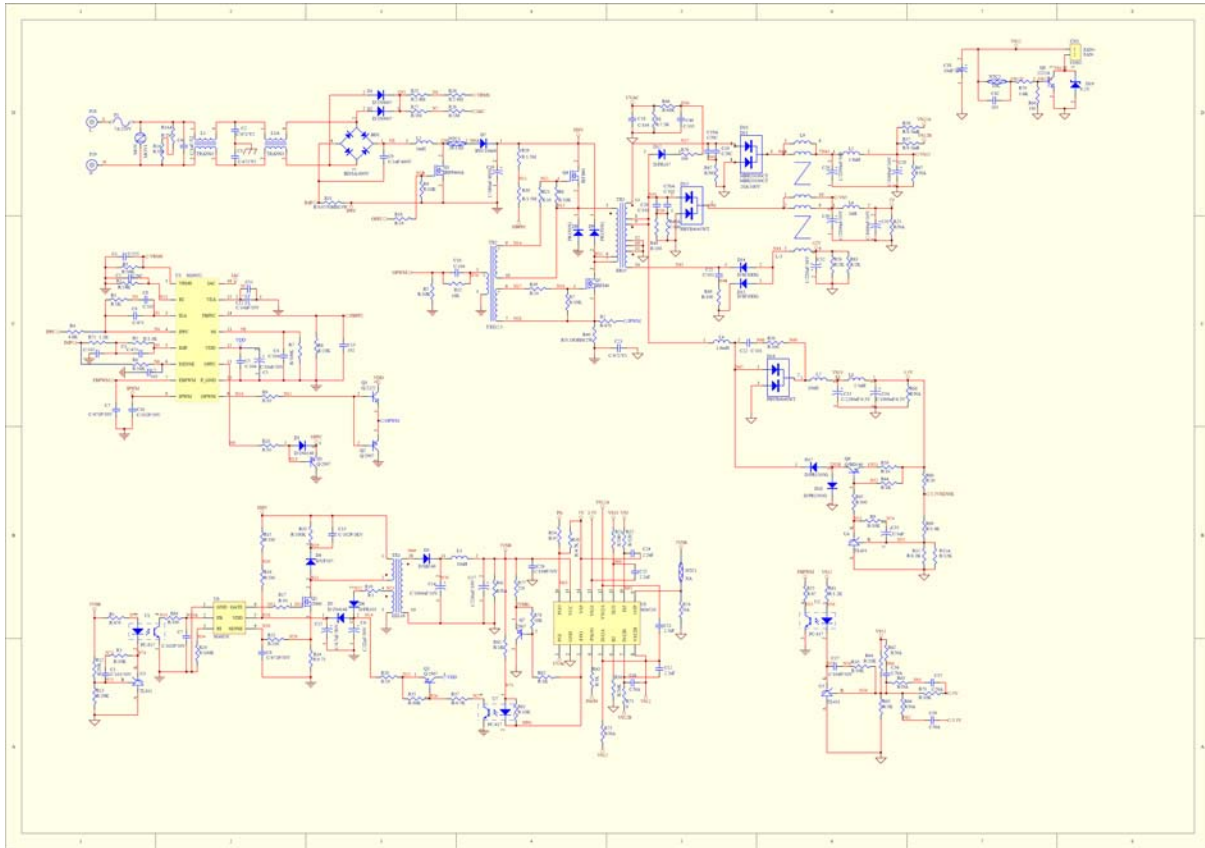


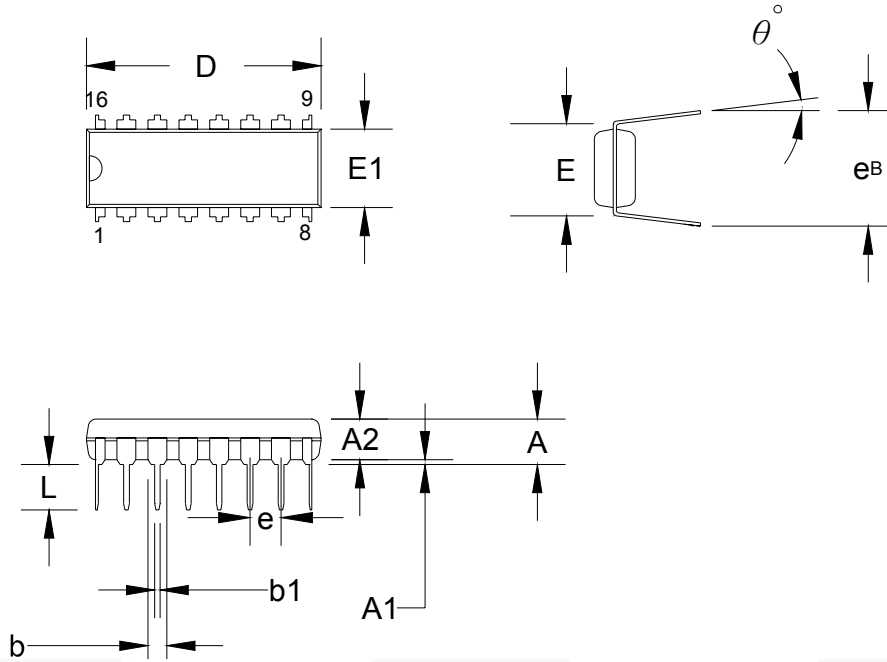
Figure 9. PCB Layout

REFERENCE CIRCUIT



PACKAGE INFORMATION

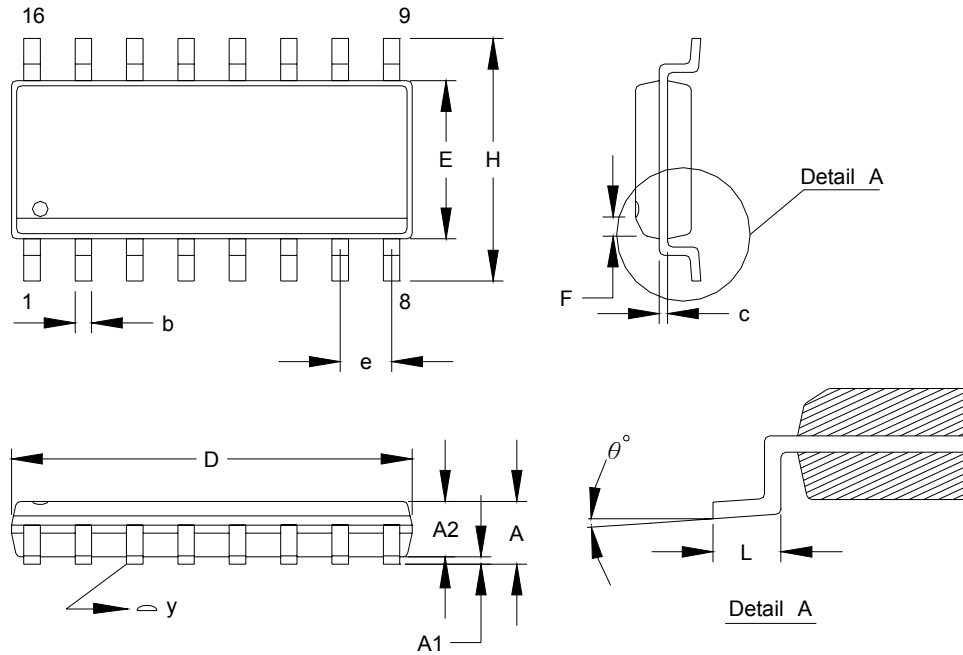
16 PINS – PLASTIC DIP (D)



DIMENSION

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.334			0.210
A1	0.381			0.015		
A2	3.175	3.302	3.429	0.125	0.130	0.135
b		1.524			0.060	
b1		0.457			0.018	
D	18.669	19.177	19.685	0.735	0.755	0.775
E		7.620			0.300	
E1	6.121	6.299	6.477	0.241	0.248	0.255
e		2.540			0.100	
L	2.921	3.302	3.810	0.115	0.130	0.150
e _B	8.509	9.017	9.525	0.335	0.355	0.375
θ°	0°	7°	15°	0°	7°	15°

16 PINS – PLASTIC SOP (S)



DIMENSION

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.346		1.753	0.053		0.069
A1	0.101		0.254	0.004		0.010
A2	1.244		1.499	0.049		0.059
b		0.406			0.016	
c		0.203			0.008	
D	9.804		10.008	0.386		0.394
E	3.810		3.988	0.150		0.157
e		1.270			0.050	
H	5.791		6.198	0.228		0.244
L	0.406		1.270	0.016		0.050
F		0.381X45°			0.015X45°	
y			0.101			0.004
θ°	0°		8°	0°		8°


Green-Mode PFC / Forward PWM Controller

SG6932



TRADEMARKS

The following are registered and unregistered trademarks and service marks Fairchild Semiconductor owns or is authorized to use and is not intended to be an exhaustive list of all such trademarks.

ACEx [®]	Green FPS [™]	Power247 [®]	SuperSOT [™] -8
Build it Now [™]	Green FPS [™] e-Series [™]	POWEREDGE [®]	SyncFET [™]
CorePLUS [™]	GTO [™]	Power-SPM [™]	The Power Franchise [®]
CROSSVOLT [™]	i-Lo [™]	PowerTrench [®]	the power franchise
CTL [™]	IntelliMAX [™]	Programmable Active Droop [™]	TinyBoost [™]
Current Transfer Logic [™]	ISOPLANAR [™]	QFET [®]	TinyBuck [™]
EcoSPARK [®]	MegaBuck [™]	QS [™]	TinyLogic [®]
F [®]	MICROCOUPLER [™]	QT Optoelectronics [™]	TINYOPTO [™]
Fairchild [®]	MicroFET [™]	Quiet Series [™]	TinyPower [™]
Fairchild Semiconductor [®]	MicroPak [™]	RapidConfigure [™]	TinyPWM [™]
FACT Quiet Series [™]	MillerDrive [™]	SMART START [™]	TinyWire [™]
FACT [®]	Motion-SPM [™]	SPM [®]	μSerDes [™]
FAST [®]	OPTOLOGIC [®]	STEALTH [™]	UHC [®]
FastvCore [™]	OPTOPLANAR [®]	SuperFET [™]	UniFET [™]
FPS [™]	 [®]	SuperSOT [™] -3	VCX [™]
FRFET [®]	PDP-SPM [™]	SuperSOT [™] -6	
Global Power Resource SM	Power220 [®]		

DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD'S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild Semiconductor. The datasheet is printed for reference information only.

Rev. I31